Chapter 1

Introducing Bluetooth

In This Chapter

From the beginning, Bluetooth technology was intended to hasten the convergence of voice and data to handheld devices, such as cellular telephones and portable computers. Through the efforts of its developers and the members of the Bluetooth Special Interest Group (SIG), it is now emerging with features and applications that not only remain true to its original intent, but also provide for broader uses of its technology.

In this chapter, and throughout this book, we provide you with a look at the Bluetooth technology, its basic design, structure, and applications, as well as the processes involved to develop and launch new Bluetooth products. We keep the very technical jargon to a minimum and give you a detailed, thorough, yet understandable look at Bluetooth and its world. In this chapter, we address the following objectives, to help you get started on the road to implementing Bluetooth technology:

- ✓ Going back to Bluetooth's beginnings
- ✓ Getting a handle on Bluetooth terminology
- ✓ Examining Bluetooth concepts

In the Beginning

Bluetooth is an open standard specification for a radio frequency (RF)-based, short-range connectivity technology that promises to change the face of computing and wireless communication. It is designed to be an inexpensive, wireless networking system for all classes of portable devices, such as laptops, PDAs (personal digital assistants), and mobile phones. It also will enable wireless connections for desktop computers, making connections between monitors, printers, keyboards, and the CPU cable-free.

The idea of a cable-free, or wireless, technology was initially conceived by Ericsson in 1994, when the company began a study to investigate the feasibility of a low-power, low-cost radio interface between mobile phones and their accessories. The company's goal was to eliminate the need for cables.

The original idea was to create a small, inexpensive radio chip that could be used in mobile computers, printers, mobile phones, and so on, to transmit data between these devices. The radio chip, of course, would replace cables. The projected cost of the chip was around $5, and it was to require low power so that it could be used in devices that rely on battery life.

About the Name

For those who know little about the technology, and even for those who are more than a little acquainted with it, the name *Bluetooth* may seem odd. You may wonder, in fact, how it relates to wireless technology, or speculate that perhaps it's derived somehow from the founding members of the SIG. Neither of these ideas is correct. The name is a romantic gesture that in some sense indicates the excitement the technology generates as well as the belief in its value as a revolutionary concept. To combine these qualities in a name required ingenuity and delving into the past.

The name *Bluetooth* comes from Danish history. Harald Blatand, who was called Bluetooth, was the son of King Gorm the Old, who ruled Jutland, the main peninsula of Denmark. By the time Harald became king, he was a skilled Viking warrior. So, when his sister asked for help to secure control in Norway after her husband died, Harald quickly seized the opportunity to unite the countries and expand his kingdom. By 960 A.D., according to the story, Harald was at the height of his powers, and ruled both Denmark and Norway. He was later credited with bringing Christianity to his Viking realm.

Although it's popularly believed that King Harald had a blue tooth, and various stories explain how this came about, it's more likely that the Bluetooth name is the English derivative of the original Viking word, *Blâtand*. The Bluetooth name was chosen for the wireless technology because its developers and promoters hope it will unite the mobile world, just as King Harald united his world.

As the idea grew, a special interest group (SIG) was formed to create a standard for this technology. The original SIG, formed in 1998, consisted of five companies:

- ✓ Ericsson
- ✓ IBM
- ✓ Intel
- ✓ Nokia
- ✓ Toshiba

Four other major companies (Microsoft, 3Com, Lucent, and Motorola) later joined this founding group to form the Bluetooth Promoter Group. Many more companies have since become part of the Bluetooth revolution, expanding on the original vision, and helping drive the development of this new technology.

Bluetooth Components

A complete Bluetooth system will require these elements:

- ✓ An RF portion for receiving and transmitting data
- ✓ A module with a baseband microprocessor
- ✓ Memory
- ✓ An interface to the host device (such as a mobile phone)

We explain these terms and concepts in the section "Bluetooth Terminology," later in this chapter.

This basic system will vary, however, depending on whether the Bluetooth module is independent of the host or embedded. First, consider the module scenario.

The RF portion can be implemented as a module or as a single chip. Ericsson has a module available that includes a short-range radio transceiver, an external antenna, and a clock reference (required for synchronization). It can be used independently or with a baseband module, which Ericsson also offers. Other transceivers also are available for Bluetooth applications, and those transceivers also can be used with another company's baseband solution or with a packaged baseband processor.

In this type of arrangement, the lower-layer Bluetooth protocols are supported in the baseband module, and the host processor must support the upper-layer protocols (for example, file transfer). In other words, the RF/baseband solution provides the means to communicate with the host, but you need to implement a connection interface, as well as any upper-layer protocols, to use applications supported by the final product.

The upper layers of the technology support what are known as the *Bluetooth profiles* — in other words, a set of protocols. A set of protocols is optimized for a class of applications — for example, dial-up networking or file transfer. This feature is issue is important, because it enables interoperability among devices. Requiring a specific profile for devices that provide comparable applications ensures interoperability across a spectrum of devices.

Another option for manufacturers is to embed a fully integrated RF/baseband Bluetooth chip. In this scenario, the upper-layer protocols reside within the single chip, freeing the host processor from the protocol processing. The cost of the chip necessarily will be higher, but the fully integrated final design can be less complex, use less power, and reduce production cost. In this scenario, the Bluetooth unit can connect to the host device through a serial interface such as a universal serial bus (USB).

Yet another possibility for implementing Bluetooth is to integrate the Bluetooth baseband module with the host system. This option would involve owning and customizing the silicon chip for the device. In this case, the device manufacturer would have complete control of interfaces and features for the device, but development costs and investment risk could be high.

Bluetooth Terminology

The Bluetooth specification, while innovative, does not define a totally new technology. In fact, Bluetooth draws heavily on existing radio communications and networking technologies, which enables it to be operationally compatible with the existing devices that also use these technologies. Many of the various terms and concepts used in Bluetooth are borrowed from other areas and included in the specification of Bluetooth's elements, such as baseband, RF communications, and many of the upper- and lower-layer protocols (a few of which have been mentioned already in this chapter). What makes Bluetooth unique is how it applies its proprietary components and the existing technologies to define its central core operations and its application profiles. Regardless of their source, the terms that are integral to Bluetooth are worth examining a little more closely.

Bluetooth stack

As already noted, the baseband, or radio module, is the hardware that enables wireless communication between devices. The building block of this technology is the *Bluetooth stack*, which includes the hardware and software portions of the system. Figure 1-1 shows a graphic representation of the stack. Essentially, the stack contains a physical-level protocol (baseband) and a link-level protocol (Link Manager Protocol, or LMP) with an adaptation layer (Logical Link Control and Adaptation Layer Protocol, or L2CAP), enabling upper-layer protocols to interact with the lower layer.

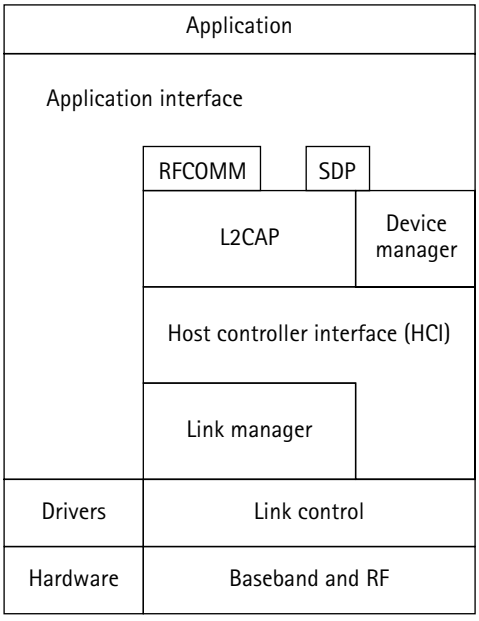

Figure 1-1: Overview of the Bluetooth stack

The Bluetooth stack has the following components:

- ✓ RF portion for reception and transmission
- ✓ Baseband portion with microcontroller
- ✓ Link control unit
- ✓ Link manager to support lower-layer protocols
- ✓ Interface to the host device
- ✓ Host processor to support upper-layer protocols
- ✓ L2CAP to support upper-layer protocols

The *radio frequency* (RF) portion provides the digital signal processing component of the system, and the baseband processes these signals. The *link controller* handles all the baseband functions and supports the link manager. It sends and receives data, identifies the sending device, performs authentication, and determines the type of frame to use for sending transmissions. The link controller also directs how devices listen for transmissions from other devices and can move devices into power-saving modes.

The *link manager*, located on top of the link controller, controls setup, authentication, link configuration, and other low-level protocols. Together, the baseband and the link manager establish connections for the network.

The *host controller interface* (HCI) communicates the lower-layer protocols to the host device (mobile computer or mobile phone, for example). The host contains a processor, the *L2CAP*, which supports the upper-layer protocols and communicates between upper and lower layers. The upper-layer protocols consist of service-specific applications that must be integrated into the host application.

Another element in the Bluetooth stack that relates to radio communications is the *RFCOMM protocol,* which allows for the emulation of serial ports over the L2CAP.

The *Service Discovery Protocol* (SDP) provides the means for Bluetooth applications to discover the services and the characteristics of the available services that are unique to Bluetooth.

The Bluetooth *device manager* provides for device inquiry and connection management services.

Chapters 3, 4, 5, and 6 provide a more detailed look at the Bluetooth protocol stack.

Links and channels

Links and channels are used to transmit data between Bluetooth units. First, the links are established. Bluetooth technology supports two link types: synchronous connection-oriented (SCO) and asynchronous connectionless (ACL) links. The SCO links are used primarily for voice

communications. The ACL links are used for packet data. Bluetooth devices can use either link type and can change link types during transmissions, although an ACL link must be established before an SCO link can be used.

After the link has been established, Bluetooth uses five logical channels to transfer different types of information between devices:

- ✓ Link control (LC) manages the flow of packets over the link interface.
- ✓ Link manager (LM) transports link management information between participating stations.
- ✓ User asynchronous (UA) carries user data.
- ✓ User isochronous (UI) carries user data.
- ✓ User synchronous (US) carries synchronous (SCO) data.

Protocols

Bluetooth protocols are sets of conventions that govern the transmittal of data in upper and lower layers of the system. The lower-layer protocols pertain to establishing connections, and the upper layers correspond to specific types of applications.

LINK CONTROL PROTOCOL

The link control protocol is responsible for delivery of the basic data elements. All packet information is transmitted in a specific time-slot format (a single time slot in the Bluetooth system lasts 625 μs), and specific links are designed to transport a range of data types.

The symbol μ is the Greek letter *mu,* and it is used to represent microseconds in microprocessor technologies.

The Bluetooth link control protocol can be used to manage the associations and delivery of information between the various units within a Bluetooth network. This format is used for both synchronous (voice) and asynchronous (data) modes of operation, with specific formats specified for voice transport.

LINK MANAGER PROTOCOL

The link manager protocol (LMP) is a command-response system for transmitting data. It transports packets through the Bluetooth baseband link protocol, which is a time-slot-oriented mechanism. LMP packets are limited in size to ensure that they fit into a single time slot.

The format of the protocol data unit (PDU) is simple. Two fields are used:

- ✓ The OpCode identifies the type and sequence of the packet.
- ✓ The content field contains application-specific information.

The LMP also specifies a collection of mandatory and optional PDUs. Transmission and reception of mandatory PDUs must be supported. Optional PDUs don't need to be implemented, but can be used as necessary.

The protocol sequences are similar to client-server architectures, with the exchange of information following a similar request-response pattern. In general, a single response PDU is sent upon receipt of the original request. Because Bluetooth is an RF broadcast technology, a set of request messages can be broadcast to all participants on a network. In this case, one request can elicit several responses.

L2CAP

Logical link and adaptation protocol (L2CAP) enables transmission of data between upper and lower layers of the stack. It also enables support for many third-party upper-layer protocols such as TCP/IP. In addition, L2CAP provides group management by mapping upper-layer protocol groups to Bluetooth networks. It also is a factor in ensuring interoperability among Bluetooth units by providing application-specific protocols.

Other protocols interfacing to the L2CAP include service discovery protocol (SDP), radio frequency communication (RFCOMM), telephony control protocol specification (TCS), and IrDA Object Exchange Protocol (IrOBEX):

- ✓ **SDP** provides service discovery specific to Bluetooth. That is, one device can determine the services available in another connected device by implementing the SDP.
- ✓ **RFCOMM** is a transport protocol that provides serial data transfer. In other words, it enables legacy software applications to operate on a Bluetooth device.
- ✓ **TCS** is for voice and data call control. It provides group management capabilities and allows for signaling unrelated to an ongoing call.
- ✓ **OBEX** is a session protocol, and for Bluetooth devices, only connection-oriented OBEX is supported. Three application profiles have been developed using OBEX: synchronization (for phonebooks, calendars, messaging, and so on), file transfer between connected devices, and object push for business card support.

Bluetooth Networking

The Bluetooth technology provides both a point-to-point connection and a point-to-multipoint connection. In point-to-multipoint connections, the channel is shared among several Bluetooth units. In point-to-point connections, only two units share the connection.

Bluetooth protocols assume that a small number of units will participate in communications at any given time. These small groups are called *piconets*, and they consist of one master unit and up to seven active slave units. The master is the unit that initiates transmissions, and the slaves are the responding units. This type of Bluetooth network can have only one master unit.

If several piconets overlap a physical area, and members of the various piconets communicate with each other, this new, larger network is known as a *scatternet*. Any unit in one piconet can communicate in a second piconet as long as it serves as master for only one piconet at a time.

Figure 1-2 shows the intercommunication between units in different piconets.

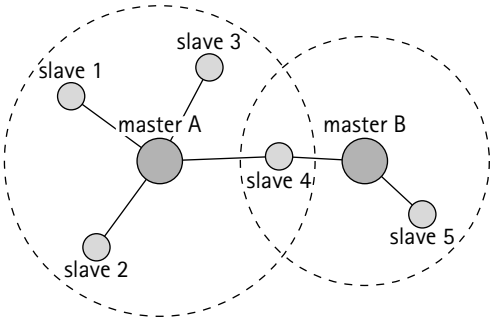

Figure 1-2: Piconets and scatternets

Bluetooth Concepts

Bluetooth is an emerging standard for wireless connectivity. It specifies a system — not just a radio — that encompasses the hardware, software framework, and interoperability requirements. And, the radio system is optimized for mobility. In other words, Bluetooth primarily specifies a cable-replacement technology that targets mobile users in the global marketplace.

Bluetooth connections

The major difference between Bluetooth wireless connectivity and the cellular radio architecture is that Bluetooth enables ad hoc networking. Rather than depending on a broadband system, which relies on terminals and base stations for maintaining connections to the network via radio links, Bluetooth implements peer-to-peer connectivity — no base stations or terminals are involved.

Using peer-to-peer connectivity, Bluetooth technology simplifies personal area wireless connections, enabling all digital devices to communicate spontaneously. Early applications are expected to include cable replacement for laptops, PDAs, mobile phones, and digital cameras. Because Bluetooth supports voice transmissions, headsets also are in line to become wireless. The Bluetooth technology offers the following advantages:

- ✓ Voice/data access points will allow, for example, mobile phone/Internet connections.
- ✓ Cable is replaced by a Bluetooth chip that transmits information at a special radio frequency to a receiver Bluetooth chip.
- ✓ Ad hoc networking enables personal devices to automatically exchange information and synchronize with each other. For example, appointments made on a PDA calendar automatically appear on a desktop calendar as well.

Figure 1-3 shows the three concepts that distinguish Bluetooth technology from other wireless connections.

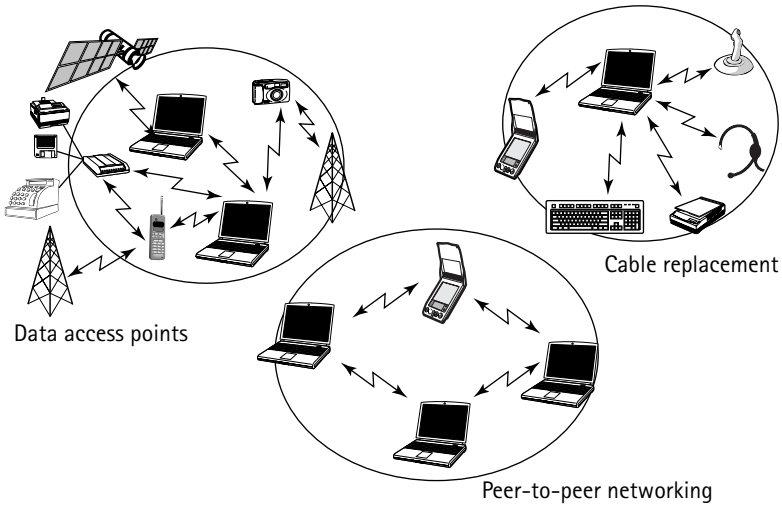

Figure 1-3: Connecting with Bluetooth

Reliable and secure transmissions

Bluetooth technology also provides fast, secure voice and data transmissions. The range for connectivity is up to 10 meters, and line of sight is not required. The Bluetooth radio unit

- ✓ Functions even in noisy radio environments, ensuring audible voice transmissions in severe conditions.
- ✓ Protects data by using error-correction methods.
- ✓ Provides a high transmission rate.
- ✓ Encrypts and authenticates for privacy.

As with any wireless interface, Bluetooth must address issues involving reliable delivery of information. Noise and interference from other ISM (Industrial, Scientific, and Medical) band transmissions, for example, are factors that come into play. To help deliver accurate information, Bluetooth provides two error-correction mechanisms: forward error correction (FEC) and automatic repeat request (ARQ). Typically, FEC is applied to voice traffic for which the timeliness of the delivery takes precedence over the accuracy — late voice traffic being unacceptable. ARQ mechanisms are used for data applications.

Because Bluetooth operates in the unlicensed ISM frequency band, it competes with signals from other devices, such as garage door openers and microwave ovens. In order for Bluetooth devices to operate reliably, each Bluetooth network is synchronized to a specific frequency pattern. The Bluetooth unit moves through 1,600 different frequencies per second, and the pattern is unique to each network.

Bluetooth also implements various security measures, including authentication and encryption. Authentication is used to verify the identity of the device sending information, and encryption is used to ensure the integrity of the data.

Chapter 17 provides more information on Bluetooth security.

Low-power architecture

Because Bluetooth is intended for mobile devices, it implements a low-power architecture in which units move into lower-power modes when not actively participating on the network. Bluetooth units also consume less power during operation. For example, the Bluetooth radio consumes less than 3 percent of the power that a mobile phone consumes.

Global compatibility

Bluetooth architecture is compliant with global emissions rules, operating on a globally available frequency band (2.4 GHz ISM band), the unlicensed portion of the radio frequency spectrum. This ensures that Bluetooth devices will interact in the same way in any part of the world.

Bluetooth architecture also complies with airline regulations and is safe for use on airlines. Developers of the technology work with the FAA, JAA, FCC, airplane manufacturers, and airlines to ensure compliance.

Interoperability, standards, and specifications

Another key concept in the Bluetooth environment is the idea of interoperability among Bluetooth units regardless of manufacturer. Because Bluetooth is an open specification for short-range wireless communication, all Bluetooth products must conform to a standard. This ensures that wireless connections will be globally available, and Bluetooth units made anywhere in the world will be able to connect with and communicate information and services to other Bluetooth devices.

To this end, the Bluetooth SIG has developed detailed specifications for the hardware and software elements of Bluetooth units. The specifications consist of Core and Profiles documentation. The Core document discusses elements such as the radio, baseband, link manager, and interoperability with different communication protocols. The Profiles document delineates the protocols and procedures to be used for specific classes of applications. The specifications are intended to prevent discrepancies in end products due to different interpretations of the Bluetooth standard.

The SIG also has implemented a qualification process. This process defines criteria for Bluetooth product qualification, ensuring the Bluetooth standards are met in any product that sports the Bluetooth name.

Chapter 2 provides an overview of the prescribed processes used to qualify a Bluetooth product.

Summary

It can be said that the name *Bluetooth* refers not only to a technology, but also to a standard and a specification. And few standards have taken off as Bluetooth has, capturing the attention and development money of major corporations throughout the world. If it can live up to its expectations and meet the needs of a global marketplace in an easy-to-use, straightforward manner, it promises to become (like its eponymous King Harald) a uniting force in the wireless communications world. This chapter helps you get started with Bluetooth technology by covering the basics:

- ✓ The origin of the Bluetooth name
- ✓ An overview of the Bluetooth components
- ✓ An introduction to the terminology of Bluetooth
- ✓ A quick look at Bluetooth networking concepts

In the next chapter, we provide a look at the Bluetooth SIG (special interest group) and its organization, including the different levels of membership available to companies that want to produce Bluetooth-related products and the processes they must follow to have a product approved.